

# **The Global Drifter Program**

## **Drifter Measurements of Surface Velocity, SST, SSS, Winds and Atmospheric Pressure**

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### **1. Project Summary**

#### *1.1) Rationale:*

The principal scientific questions of the role of the ocean in climate change are how well can we describe or model the present climate of ocean circulation and how well can these descriptions or models predict the evolution of future climates. A principal climate index of oceans is sea surface temperature (SST) whose evolution is both forced by the atmosphere and is the cause of atmospheric climate change. A global array of drifters provides the operational instrumental data sets for describing ocean surface circulation and SST evolution. These data are also used for testing climate models and enhancing long-range weather prediction and interannual climate change. Sensors that measure sea surface salinity (SSS) can now be added to drifters and these SSS data are critical to determining the oceans' fresh water cycle and onset of deep-water renewals. Atmospheric pressure measured on drifters is assimilated into weather prediction models and is used by operational meteorological agencies to discern severe weather conditions over the oceans. Wind sensor and subsurface temperature chain data are used to improve prediction of tropical storm and hurricanes. Drifters designed, manufactured and deployed by the Global Drifter Program have proven to be reliable, autonomous platforms for obtaining climate and operational weather data from the global oceans.

#### *1.2) Objectives of the Global Drifter Program:*

The "Global Drifter Program" (*GDP*) is the principal international component of the Joint Commission of Marine Measurements (JCOMM) "*Global Surface Drifting Buoy Array*". It is a "Scientific Project" of the Data Buoy Cooperation Panel (DBCP) of World Meteorological Organization (WMO)/International Ocean Commission (IOC). It is a near-operational ocean-observing network that, through the ARGOS satellite system and the Global Telecommunication System (GTS), returns real time data on ocean near-surface currents, SST and atmospheric pressure (and winds, subsurface temperature,  $T(z)$ , and SSS) and provides a data processing system for scientific utilization of these data. In addition to *GDP*, drifters are deployed by operational oceanographic and meteorological agencies and individual scientific research projects, whose data are utilized by *GDP*. In turn, *GDP* data are made available to operational users and scientists at large. Wind-sensors, salinity sensors and thermistor chains are added to SVP drifters, presently on a limited basis for specific operational and research requirements. The international protocols for these data exchanges and sensor additions are worked out each year by DBCP.

The scientific objectives of the *GDP*, and its operational and research partners, are:

- 1) Provide to GTS a near-operational, near-real time data stream of drifter position, SST, and sea level pressure. GTS compatible data on winds,  $T(z)$  and SSS are also provided on operational basis when these sensors are mounted on the drifters.
- 2) Observe the mixed layer velocity on a global basis with  $0.5^\circ$  resolution and, jointly with satellite altimeter data, produce charts on the seasonal and interannual changing circulation of the world ocean at  $0.5^\circ$  resolution (Figure 1)
- 3) Develop and introduce into the drifter construction technological advances in sensors, electronics, power, methods of assembly and deployment packaging.
- 4) Provide enhanced research quality data sets of ocean circulation that include drifter data from individual research programs, historical data from instruments different from the Surface Velocity Program (SVP) Lagrangian Drifter and the corrected data sets for wind-produced slip of drifter velocity. To this end *GDP*:
  - Provides to the coupled ocean-atmosphere climate modelers gridded, global data sets of SST, near surface circulation and dynamic topography for assimilation and the verification of the parametrized processes, such as wind-driven Ekman currents and spatial patterns of the seasonal circulation.
  - Provides the Lagrangian data sets for the computation of single particle diffusivity, dispersal of ocean pollutants, the enhancement of models of fisheries recruitment and improvement of air-sea rescue.
  - Obtains high-resolution coverage of ocean variability and time mean circulation in support of ENSO prediction model verification in the tropical Oceans and supports short-term research projects that require enhanced upper ocean velocity observations.

### *1.3 Required Drifter Observations and Status of Global Array*

The ‘required’ global drifter array size by JCOMM is based on the need to maintain 1250 platforms that return instrumental observations of daily average SST ( $\pm 0.1^\circ\text{C}$ ) over the global ocean at a  $5^\circ$  resolution, or the spatial scale of the error covariance function of the

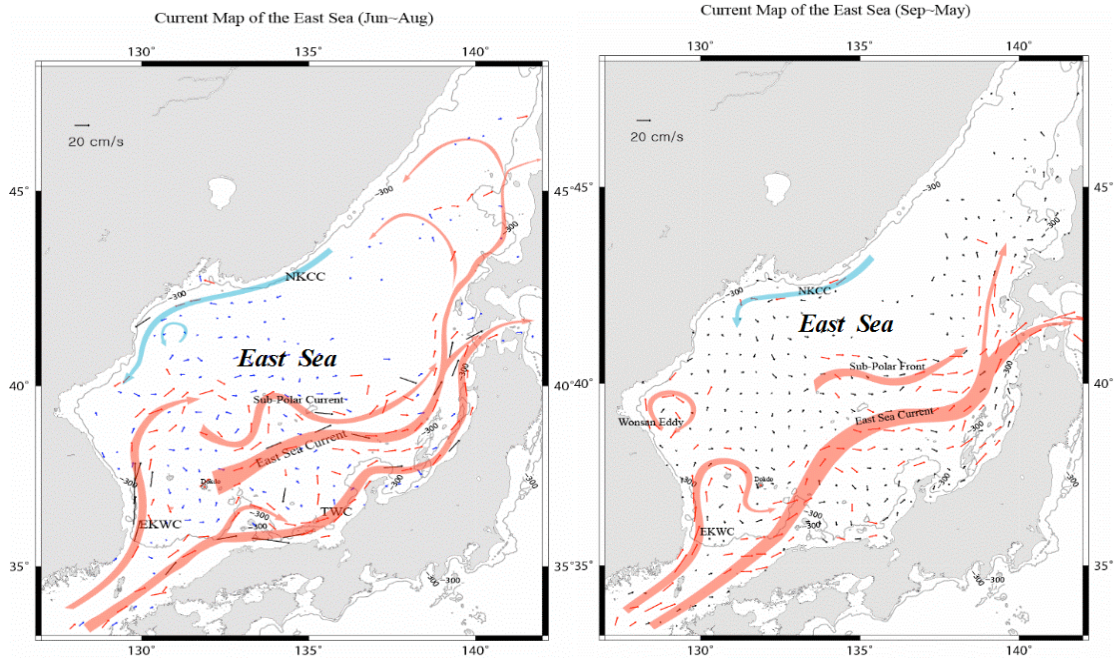


Figure 1. The East Sea seasonal mean surface current patterns in June-August (left panel) and September-May (right panel) derived from 310 drifters deployed in the period 1996-2006 within the ONR/NOAA/Korean joint study of seasonal circulation in the East Sea. Black arrows are for mean currents  $> 20$  cm/sec, red arrows are for mean currents  $> 10$  cm/sec and  $< 20$  cm/sec and blue arrows are for mean currents  $< 10$  cm/sec.

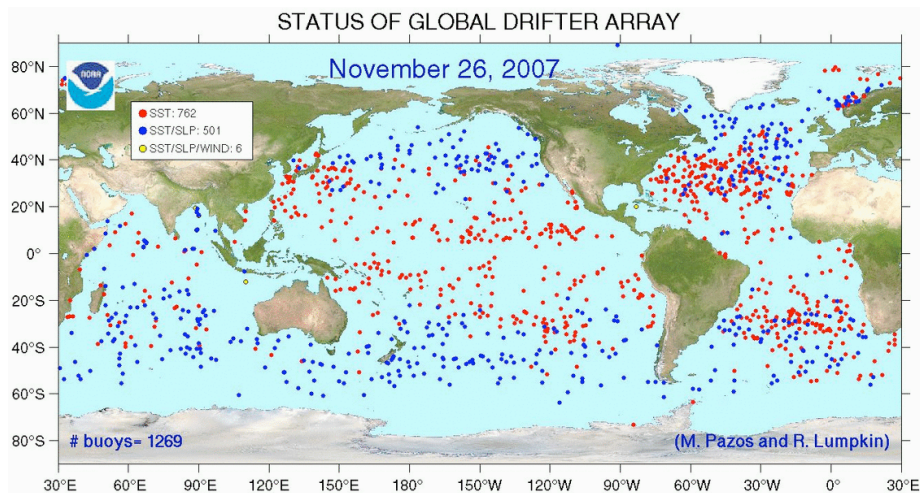


Figure 2. Status of the Global Drifter array on 26 November 2007. Special scientific programs have increased the density of drifters in the North and South Atlantic basins.

operational NOAA satellite infrared SST sensors. The implementation of the required global array for SST observations was completed in September 2005 with the deployment of the 1250<sup>th</sup> element of the global array (Fig. 2). Surface pressure sensors are supported by regional meteorological agencies based on regional needs. The number of drifters in the array is composed of the NOAA supported *GDP*, research principal investigator enhancements who have requested their data to be included in the *GDP* real-time data base and international partners

On 26 November 2006, 1269 drifters were reporting to GTS and to the Atlantic Oceanographic and Meteorological Laboratory (AOML) *Drifter Data Center* (Figure 2). In FY'07, the NOAA Climate Observations Program funded to JIMO (920) and AOML (80) sufficient numbers of SVP drifters, and with the contributions of drifters (100-120) from other national and international sources, the array was maintained from late 2005 to present date at the desired level (Fig.3). In 2008 the efforts will continue to adjust the array spatial density with the desired the surface of the ice-free ocean at 5° resolutions.

The international science bodies, such as JCOMM, request that the drifter array provide instrumental observations of SST and the operational meteorological agencies desire to obtain atmospheric pressure observations from as many drifters as possible. To this latter end, the DBCP (October'06) requested these meteorological agencies begin to provide funds to attach a barometer to every SVP drifter. By November 2007, over 500 drifters provide barometer sensor data on to GTS. For the past 20 years, most drifters in research program have been justified on the basis of velocity observations, where 99% of reviewed scientific research papers make principal use of drifter velocity observations (viz: [http://www.aoml.noaa.gov/phod/dac/drifter\\_bibliography.html](http://www.aoml.noaa.gov/phod/dac/drifter_bibliography.html)). In early December 2007, the CLIVAR Velocity Working Group will consider the requirements of climate research for global velocity observations.

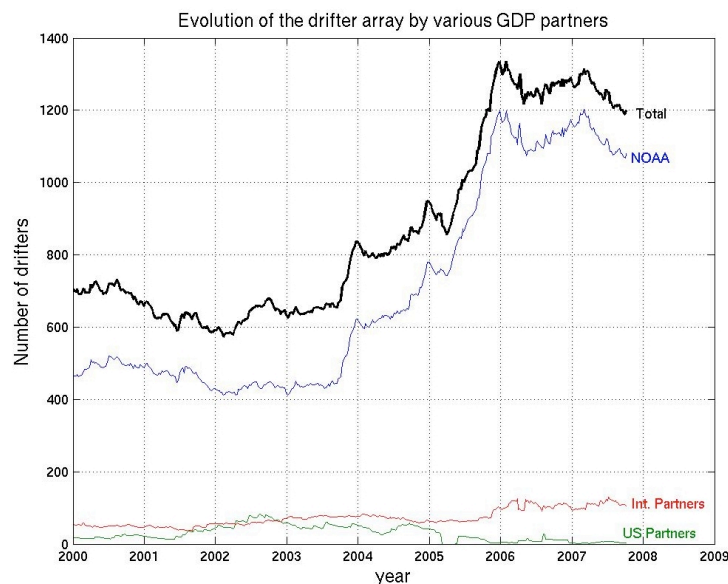


Figure 3. The evolution of the GDP drifter array as reported on GTS.



#### *1.4 Management:*

*GDP* reports every year on its activities relative to advances in technology in the DBCP Technical Session and its deployment plans and management in the DBCP Plenary Session. *GDP* is largely a NOAA funded program and is managed according to the “*Ten Climate Monitoring Principles*” established by JCOMM. In these management tasks, the principal investigator of this proposal, Peter Niiler, assumes the responsibility for the coordination between the following entities:

- US manufacturers in private industry (*Technocean, Inc.* of Cape Coral, FL; *Clearwater, Inc.* of Watertown, MA; *Pacific Gyre, Inc.* of Carlsbad, CA) who build the SVP drifters according to closely monitored specifications. Internationally, a total of 6 private firms and 3 research laboratories build SVP drifters. Periodically, drifter construction manuals are upgraded and are posted on the DBCP website (e.g. 2005 the SVP-B Mini Construction Manual). As reflected in the FY’08 budget, small increases (2.85%) for SVP-Mini drifter construction costs over FY’06 budget were allocated in FY’07. This represents the second year of a small adjustment.
- Atlantic Oceanographic and Marine Laboratory (AOML) who carries out the deployments at sea, processes the data and archives these at MEDS, Canada, maintains the META file on the description of each drifter deployed and the upgrades the *GDP* website.
- Technical staff of SIO, who assist in the supervision of aircraft deployments of drifters into hurricanes, place orders for the NOAA funded drifters, upgrade the technology, develop new sensors, enhance the data sets and maintain liaison with individual marine research programs that deploy SVP drifters.

This continuing proposal from JIMO addresses the progress of activities in FY’07 and proposes the activities for FY’08.

## **2. FY’07 Progress**

In FY’07 NOAA Grants office funding of the *GDP* through JIMO occurred in the last week of September 2007. The designated date for the start of the FY’08 funding of *GDP* is 1 July ’08, but as has been the case in the past five years, we do not anticipate that the NOAA Grants Office is capable of meeting that date. This is a report of what was accomplished with both the FY’06 and FY’07 funding during the period of October 2006 - November 2007:

*2.1) Summary of Drifter Acquisitions and Technology: With the FY’06 funds 940 drifters with SST sensors were built and were delivered to AOML for deployment. With the FY’07 funds, 920 drifters were ordered in October 2007 and are now being delivered to AOML for deployment. In August 2007, all 12 drifters deployed into category 4 Hurricane Dean worked well (4 were SVP-W wind drifters and 8 were SVP-W-T(z) wind and thermistor chain drifters). All 20 air deployable drifters ordered in ’06 were delivered to Keesler*

*AFB for deployment for the 2007 hurricane season. Because only one hurricane was sampled in 2007, there now are 36 SVP-W-T(z) and 16 Minimet drifters at Keesler AFB fully rigged for air-deployment. When in June 2008 an additional 8 SVP-W-T(z) and 12 SVP-W drifters will be delivered to Keesler AFB, there will be 72 hurricane drifters available for the '08 Hurricane season.*

*With the FY'07 funds:*

- a) A total of 650 SVP-Mini drifters and 270 SVP-B barometer drifters were ordered from Clearwater Instruments, Inc Pacific Gyre, Inc. and Technocean, Inc. These are now being delivered to AOML for deployment.
- b) A total of 12 SVP-W wind-drifters and 8 SVP-W-T(z) wind and thermistor chain drifters, fully rigged for air deployment, were ordered from Pacific Gyre, Inc. All 20 units will be delivered the 53<sup>rd</sup> Air Force Reserve "Hurricane Hunter Squadron" at Keesler AFB before June 1, 2008. Dr. Rick Lumpkin at AOML are , working closely with the National Hurricane Center at AOML, organizes the deployment of what will now be 72 hurricane drifters in the 2008 hurricane season.
- c) In October 2007, 5 refurbished SVP drifters with salinity sensors were deployed in off the coast of South America in the Amazon plume by the French oceanographers.

**In FY'07 JIMO purchased 920 drifters and AOML purchased 147 drifters, for total NOAA contribution of 1167 drifters to the JCOMM "Global Surface Drifting Buoy Array".**

*2.2) Enhanced Data Sets and Publications: Between October 2006 and December 2007, there were 17 requests for enhanced drifter velocity data sets. Dr. Yoo Yin Kim who works under the direction of P. Niiler as a Senior Statistician prepared and distributed these data. The drifter peer-reviewed publication list was upgraded in December 2006: ([http://www.aoml.noaa.gov/phod/dac/drifter\\_bibliography.html](http://www.aoml.noaa.gov/phod/dac/drifter_bibliography.html)).*

*2.3) Meetings and Lectures: The following personnel participated in the GDP presented lectures or attended the following organization meetings:*

- DBCP-XXIII, October 15-20, 2007 Jeju, Korea: "Observations of Atlantic Hurricanes with Air-deployed Drifters" (Peter Niiler and Rick Lumpkin)
- DBCP-XXII, October 15-20, Jeju, Korea: "The Global Drifter Program Report" (Peter Niiler for Rick Lumpkin)
- DBCP-XXIII, October 15-20, 2007, Jeju, Korea: "Drifting instrumented chains. New technical developments and application (L.R. Centurioni and P.P Niiler)
- North Pacific Drifter Implementation Group

*2.4) Technical Development of Thermistor Chains for Hurricane Drifters: Working with Clearwater Instruments, Inc. we have designed and assembled the components for a new 150 m long thermistor chain/barometer drifter (Fig.4) that can be deployed from the*

AXBT chute of a P-3 research or military aircraft. Two prototype systems for the SVP-B-T(z)-Mini will be assembled in early 2008 and tested off the coast of La Jolla, CA. We anticipate that with the FY'08 funds half of the hurricane drifters will be of this new design.

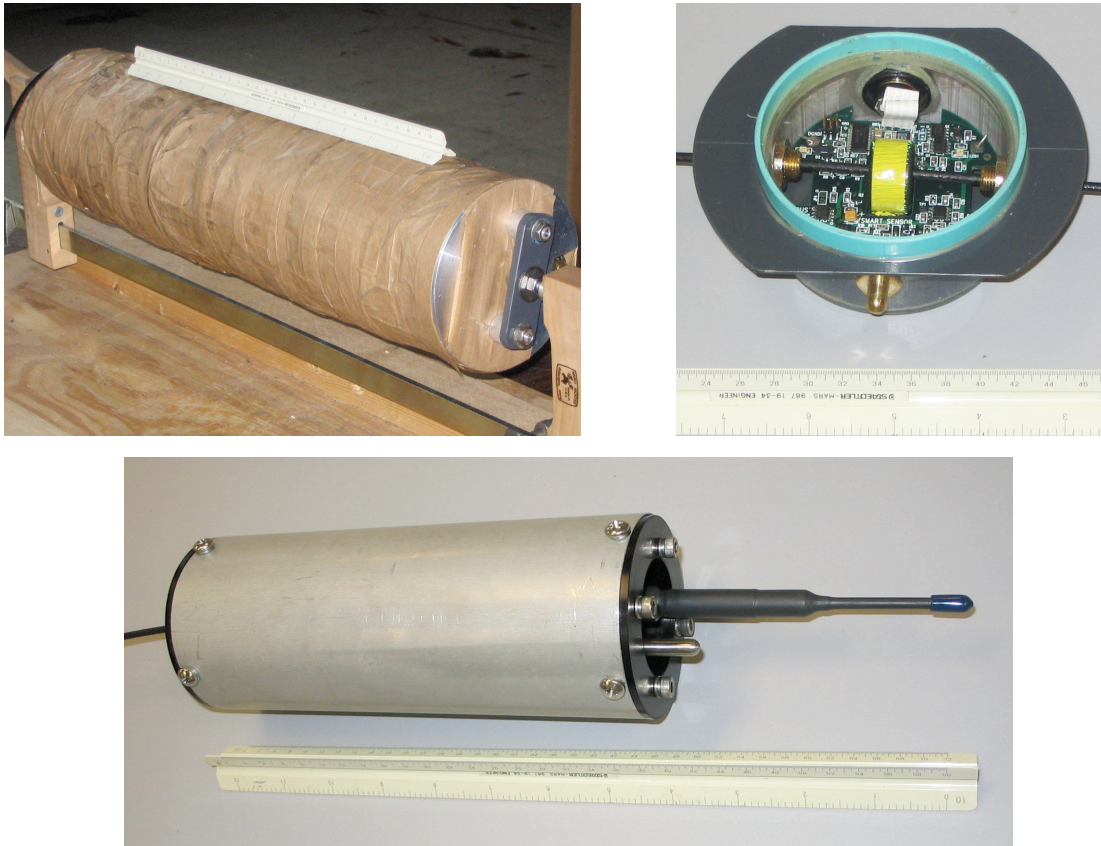


Figure 4. Prototype components of the SVP-T(z)-Mini with 150m, 10 sensor spool (left), T sensor (right) and container for GPS/Iridium antenna and electronics (center bottom) for SVP-TC Mini. Note the size of these components relative to a 1ft. ruler in each photo.

Peter Niiler initiated the request for development of a station keeping sensor system to NOAA/OCO and serves as a technical reviewer to the NOAA/SBIR entitled: “Station Keeping Drifting Data Buoy for Ocean and Meteorological Data Retrieval in Severe Marine Environment”. LBI Corp. or Groton CN is the lead contractor for this SBIR

*2.5) Collaborations:* Collaborations are continuing for deployment of drifters with the Office of Naval Research (30 SVP-GPS drifters purchased by ONR were released in the East China Sea in October 2007) and analysis of East Sea drifter data from a joint ONR/GDP/Korea circulation study of the Western Pacific from 1996-2006 (viz. Fig.1). The Korean National Ocean Research Institute (NORI) has implemented an operational surface current map based on the mean velocity derived from these drifter data to which

is added a time variable component based on altimeter and winds. These maps are routinely used by the Korean Coast Guard for aid in rescue of ships in distress (viz: <http://makaha.ucsd.edu/MyWeb/NORI/recent.pdf>)